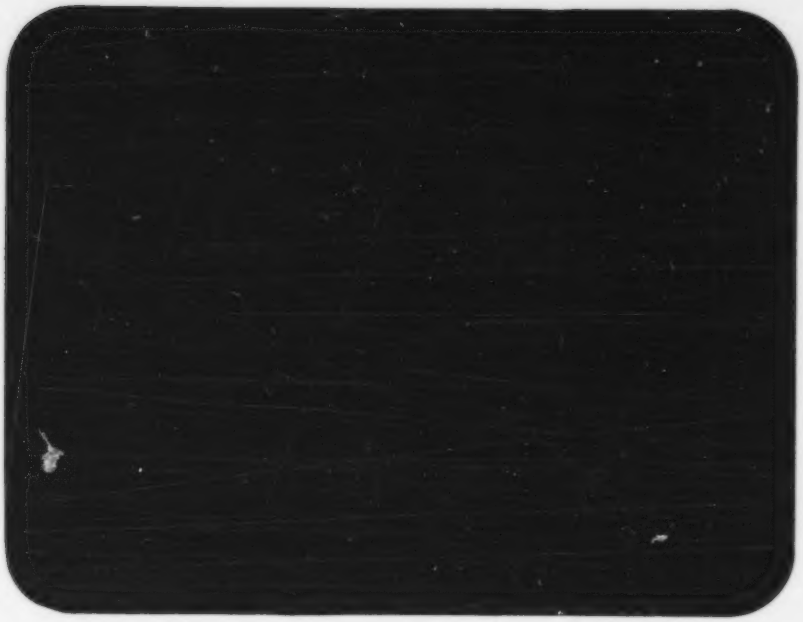


Province of British Columbia
Ministry of Forests

F.S.189(1)INF 81/2

MINISTRY OF FORESTS
GUIDELINE TO SELECTING
PARENT TREES IN B.C.

90-04746/

CONTENTS

	PAGE
ACKNOWLEDGEMENTS	1
INTRODUCTION	2
PLANNING PARENT TREE SELECTION ACTIVITIES	3
METHODS OF SELECTION	6
CRITERIA FOR SELECTION OF PARENT TREES	9
COMPLETION OF THE PARENT TREE RECORD FORM	11
MARKING OF PARENT TREES	20
REGISTRATION OF PARENT TREES	22
REFERENCES	24
APPENDICES	25

ACKNOWLEDGEMENTS

The following guideline has been prepared based on the inputs of members of tree improvement, seed orchard, and ecological classification staff working within the Ministry of Forests. Members of other agencies such as Forest Co. staff, Forintek Canada Corp., University fo B.C., and Canadian Forestry Service have provided review comments and specific instruction materials.

It is intended that through the continued review and inputs of all concerned that this guideline can be periodically updated for more effective use by field staff involved in parent tree selection.

INTRODUCTION

The purpose of this guideline is to introduce Ministry of Forests, and Forest Company and other field staff to the concepts and procedures of parent tree selection. It is intended for province-wide use and is thus generalized to encompass the various selection approaches presently employed. Details of each approach are not discussed and supplemental workshops are therefore required to review selection procedures for specific projects or species in greater detail. Geneticists and field staff experienced in parent tree selection work are best qualified to conduct such workshops.

Parent tree selection activities described in this guideline are presented in their normal order of occurrence. Recommended planning procedures are first discussed. Various field selection methods employed in B.C. are then briefly reviewed. These vary from very intensive to extensive and considerations are presented to help determine which method is most appropriate. Selection criteria pertaining to most conifer species in B.C. are provided. These criteria are, of necessity, general and may require further refinement during selection workshops. Instructions to complete the Parent Tree Record form and mark selected trees for field identification are presented. Finally, registration procedures for newly selected parent trees are outlined.

PLANNING PARENT TREE SELECTION ACTIVITIES

The selection of parent trees is commonly the initial step of a comprehensive, long-term tree improvement program. The success of future breeding and seed orchard activities is largely dependent on this initial selection phase and it is thus most important that selection projects receive careful planning.

It is anticipated that most future selection projects in B.C. will contribute to cooperative tree improvement programs. The first planning step must therefore be consultation with the individual responsible for coordinating all selection activities. At this time the precise selection area and elevation band (or biogeoclimatic subzone) must be delineated and the number of trees to be selected specified.[1] In addition, consideration should be given to the distribution of the selected trees. If little provenance test[2] information exists it is often recommended that parent trees be well-distributed along geographic/elevation/ecosystem gradients. Presumably the selected trees will then embrace much of the genetic variation produced from differing natural selection pressures. Future seed production in orchards originating from these trees can then be assumed widely-adapted and suitable for reforestation throughout the intended use-age area.

If, however, provenance test information is available superior populations should recieve a greater selection emphasis. Provenance test sites may, in fact, themselves serve as sites for selection. In addition, population

---

[1] Formalized coordination procedures are now followed in the Coastal Tree Improvement Cooperative program.

[2] Underlined technical words in the text are defined in Appendix I.

genetics research may indicate that much of the existing genetic variation lies within, not among, forest stands. In this situation, it may be agreed that little can be gained from sampling a large number of populations and selections should be grouped into a relatively few number of areas. If parent trees are to be selected in close proximity, a minimum distance separating these trees should be specified.

Once the selection area, number and recommended distribution of parent trees has been finalized, forest cover and/or operations maps and aerial photos can be studied to initially screen stands with selection potential. Stand selection criteria discernible on these maps and photos include:

1. Stand Age

Stands should preferably be between ½ and full-rotation age. Phenotypic variation is commonly greater at this age than in mature stands and selection of superior phenotypes thus facilitated. Cuttings and/or scions are also generally of better quality in younger stands.

A preponderance of old growth stands in a selection area will make it impossible to always fulfill this criterion.

2. Age Distribution

Even-aged stands are more preferred sites for selection than those that are uneven-aged because tree height and diameter are more likely attributable to genetic factors rather than age differences. It is for example difficult, if not impossible, to interpret superiority when the candidate tree is older than adjacent comparison trees.

3. Species Composition

Stand composition should be primarily of the intended species because there is a greater likelihood of locating dominant comparison trees of the same species near the candidate tree. Proximate comparison trees (e.g. within

a radius equal to candidate tree height) are desirable because they are more likely to have experienced a similar environment and thus offer a more accurate comparison of genetic differences.

4. Stand Distribution

If it is pre-determined that parent trees should be distributed along geographic/elevation/ecosystem gradients efforts should be made to ensure that stands identified on maps and aerial photos are also well-dispersed along these gradients. Selection of stands across the indicated range of site qualities should promote a thorough ecologic sampling. Good and medium sites are however generally preferred locations for selection because phenotypic variation is more pronounced.

5. Site and Stocking Uniformity

Uniformly stocked stands which grow on homogeneous sites are highly desirable locations for selection work because phenotypic variation is less influenced by environmental irregularities. Selections can therefore be made with greater confidence of genetic superiority. Aerial photos are best used to locate uniform stands or portions of stands.

Once the field work commences it is of course important to further screen stands that have been selected solely from an examination of maps and photos. A quick appraisal of general phenotypic quality should be completed within a stand prior to selecting parent trees. Those stands which exhibit negative characteristics not visible on maps or aerial photos (e.g. poor stem quality) can then be further weeded out.

METHODS OF SELECTION

Historically, during the 1950's and early 1960's, initial selection work in B.C. focused upon coastal Douglas-fir. An intensive plus tree selection method (described below) was employed to locate trees that met very high selection standards. This work was however time consuming and expensive and doubts were expressed as to whether such an intensive approach was jusitifed. In more recent years less intensive parent tree selection methods have commonly been adopted. Trees selected today seldom exhibit the same superiority as the original plus trees and are commonly termed parent trees.[3]

The specific selection methods that have most often been employed in British Columbia can be summarized as follows:

1. Plus Tree

This selection method employs an intensive 100 percent cruise. Parallel compass lines are traversed by a compassman at intervals (e.g. every 30 metres) which will enable one or two plus tree cruisers to observe every tree in the stand. Promising candidate trees are first flagged and then reinspected. The most impressive are evaluated quantitatively by comparison with at least three surrounding dominant trees. Those candidates which exhibit the greatest superiority are then selected as plus trees.

---

[3]Selected trees are referred to as parent trees in this guideline, rather than plus trees, because of the almost total adoption of parent tree selection methods in recent years.

2. Parent Tree

(i) Within stand - the entire stand area is generally traversed. However, the stand inspection is less structured than the plus tree method and no attempt is made to observe every tree. Candidate trees are commonly evaluated quantitatively by comparison with one to three surrounding dominants.

(ii) Roadside - as the name implies trees are selected along stand perimeters which border roads. Minimum effort is thus devoted to within stand examinations away from the roadside. Candidate trees are commonly first identified from a slowly moving vehicle (based on height superiority). Other traits are them evaluated visually and, if still acceptable,the tree is evaluated quantitatively, often against measurements of a single dominant tree. This method is a quicker and less intensive than the within stand parent tree method.

(iii) Aerial - this method entails the selection of trees from a helicopter. Stands are quickly "cruised" from just above the canopy level and trees selected following a quick appraisal of superiority from the air. The aerial method is the least intensive parent tree selection method and can not be expected to yield selections that are much superior to representative dominants in the stand because of the quick selection time and restricted number of traits that can be evaluated from a helicopter. Scions or cones are often collected at the time of selection (when these operations can be scheduled). A safety plan for use of a hydraulic pruner to collect these materials from a helicopter has been approved by the Worker's Compensation Board and is available from the Silviculture Branch, Ministry of Forests.

The choice of the most appropriate selection method for a particular species and selection area demands consideration of many factors. Final decisions are therefore best made in consultation with geneticists and other indi-

viduals with selection experience. Some important considerations include heritability, logistics and time constraints.

Heritability is a measure of the extent to which a trait is influenced by heredity as compared to environment. As this parameter increases phenotypes become more indicative of genotypes and intensive selection methods more attractive because significant genetic gain can often be achieved simply by intensively selecting few, very high quality parents. Conversely, if heritability is low, the increased genetic gain from an intensified selection effort will be reduced. A common strategy in this situation is the selection of many parents at a low intensity coupled with an early progeny testing program to more accurately evaluate parental genotypes. The best parents are then reselected on the basis of the progeny test results.

Heritability varies primarily according to species and trait of selection. It is however also influenced by stand and site conditions. Even-aged, uniform stands growing on homogeneous sites exhibit less environmental variation and relatively high heritabilities. These stands are thus preferred locations for a more intensive selection effort.

Logistically, the more distant and/or difficult access to a selection area the less intensive the selection effort that can generally be expended. The least intensive approach, the aerial method, was developed to adequately sample remote and restricted access areas in central B.C.

Certain constraints can also limit the time available for selection and thus prompt the adoption of a quicker, less intensive method. If, for example it is desirable to collect cones from parent trees at time of selection all activities may have to be completed in a short three of four week period. An intensive selection effort would probably be too time consuming if more than a very few number of trees must be selected.

CRITERIA FOR SELECTION OF PARENT TREES

The following is a list of general selection criteria considered applicable to most conifer species in B.C. These criteria should be reviewed prior to the selection work (e.g. at parent tree selection workshops) and, if necessary, further refined to meet specific species requirements.

1. Vigour

Parent trees should exhibit a superior rate of growth. Total height and diameter are indicative of vigour. Height is however less influenced by surrounding competition and considered a more accurate measure of inherent vigour. Recent height growth should also be at least comparable to the stand average especially if the candidate age is less than the anticipated future rotation age.

2. Health

Parent trees should be healthy. If a particular pest is common, some infestation/infection may be tolerated providing incidence appears low when compared to other trees in the stand.

3. Stemform

Selected trees should be free of forks, crooks, sweeps, spiral grain and pronounced taper. On some sites, particularily at higher elevations, sweep is a natural occurrence and is therefore acceptable. Repeated crooks and double sweeps should however always be avoidable.

4. Branch/Crown Characteristics

Parent trees should exhibit narrow crowns (relative to competition) with few and fine branches. Branch angle in mid-crown should be near horizontal and, under competition, the stem should exhibit evidence of good natural branch pruning.

5. Scion Quality

Parent trees must yield sufficient, good quality scion material from the upper crown to satisfy propagation requirements. It is thus advisable that the approximate number of scions required from each parent tree be determined prior to selection activities in order that this criterion can be more accurately evaluated. Scion quality in some stands may generally be poor (e.g. stands that are mature or have recently produced a heavy cone crop) and this trait may become a prime selection criterion. Examples of good, acceptable and poor interior spruce scion material are illustrated in Appendix II.[4]

6. Wood Quality

Wood quality may or may not be evaluated depending on species and selection procedures. It is not possible to evaluate this trait at the time of selection -- wood cores must be sampled as per instructions provided in Appendix III and subjected to laboratory analysis. The necessity of wood core collection should be reviewed at selection workshops.

7. Cone Production

Parent trees should show a willingness to flower, especially if other trees on the site are bearing.

Attainment of all the above selection critera for each parent tree would be a most difficult task requiring a very intensive selection effort. The above criteria are therefore listed in approximate order of importance to aid trade-off decisions (thus, vigour should recieve more selection emphasis than cone production). It should also be apparent from these criteria that the best tree in the stand is not usually the largest. Stemform, branching and health are also important. Thus, well-formed, healthy trees with some size superiority should be favoured over the largest "wolf trees".

---

[4]Consult the Coastal Tree Improvement Standards for further information regarding scion quality.

COMPLETION OF THE PARENT TREE RECORD FORM

A Parent Tree Record Form is presented on page 12 . Numbers 1-48 are indicated alongside the items and completion instructions for each follows below. All dark and light shaded items on the form represent the minimum completion requirement for each tree selected from the ground. The dark shaded items represent the minimum for aerial selections. Completion of the remaining items is not mandatory unless specified during selection workshops. The unshaded ecological information is however valuable and should be completed if at all possible.

1. Species

The species (common name) of the parent tree is entered here.

2. Local No.

This is a temporary number used during the field selection phase of operations pending registration of the parent tree.

3. Registration No.

This is a permanent number that will be assigned by the Ministry of Forests administrative centre. The permanent registration number will replace the local number.

SITE/STAND INFORMATION

4. Biogeoclimatic Zone/Subzone

This information may be obtained from the appropriate ecologic maps. The zone will be denoted by capitals and the subzone by lower case letter (e.g. ESSFa).

5. Location by Edatopic Grid

See Appendix IV for an illustration of the Edatopic Grid and description of procedures to determine particular site's position on this grid. Complete this item as best as possible.

PARENT TREE RECORD [1]

Registration No. Sp. ___ No. (3)

Species (1) _____ Local No. (2) _____

SITE/STAND INFORMATION

Biogeoclimatic Zone/Subzone (4) _____ Edatopic Grid Position (5) _____ Ecosystem Association (6) _____

Landform (7) _____ Soil Texture (7) _____ Aspect (8) _____ Slope (9) _____

Species Composition: (10) _____ Stand Density: Open ◯, Medium ◯, Dense ◯ (11)

Main Species Vigour: Thrifty , Good , Stagnant , Deteriorating (12)

Age Distribution: Even Aged , Two Aged , Multiaged (13)

Origin: Artificially Regenerated , Natural (14)

Site/Stand Comments (15) _____

PARENT AND OTHER DOMINANT TREE INFORMATION

FEATURE	PARENT TREE	DOM 1			AVG. OF DOMINANT
DBH O.B. (cm) (16)					
Double Bark (cm) (17)					
DBH I.B. (cm) (18)					
Height (m) (19)					
Total Age (20)					
Stem Form* (21)					
Branch Angle* (22)					
Cone Crop* (23)					
Wood Specific Gr. (24)					
Competition (Prism BAF_____) (25)					

*Coded Rating System

Stem Form	Value	Branch Angle (from Horizontal)	Value	Cone Crop	Value
Straight	5	0-30°	4	Heavy	4
Lean	4	31-60°	3	Medium	3
Basal Sweep	3	61 + °	2	Light	2
High Sweep	2	Drooping	1	None seen	1
1 or more Forks	1				

Reasons for Selection (26) _____

[1] Minimum completion requirement:

Aerial Selection - all shaded items Ground Selection - all and shaded items

FS 731

Registration No. Sp. No. (3)

Local No. (2)

LOCATION INFORMATION

Country (27) Prov./State (28) Nearest Named Geographic Feature (29)

Elevation (30) m Orchard Planning Zone (31) Orchard Number (32)

Latitude (33) ° Longitude (34) ° UTM Grid (35)

Forest Region (36) Forest District (37) Forest Unit (38)

LOCATION SKETCH (indicate north)

(39)

GENERAL LOCATION MAP (indicate north)

(40)

Approx. Scale

Scale

Description of Access (41)

Plotted on: (42) Photo No. Mapsheet No. Operations Map No.

Tree Identified by: Paint , Ribbon , Tag , Top Flag (43) , Other

SELECTION/COLLECTION INFORMATION

Parent Tree: Selected by (person) Agency Date (44)

Approved by (person) Agency Office Field

Selection Method: Plus tree ; Parent tree-within stand , roadside , aerial (45)

Material Collection: (46) Scions ◯ , Date , Cuttings ◯ , Date

Cones ◯ , Date , Other Date

Parent Tree Status: Standing ◯ Felled/Destroyed ◯ (47) Date

Form checked/data coded by (person) (48) Date

6. Ecosystem Association

If ecosystem associations have been projected onto the edatopic grid in the selection area record the appropriate association name.

7. Landform/Soil Texture

Complete these items as best possible. Examples of landform/soil texture types as illustrated in Appendix IV. Look for upturned stumps, road cutbanks etc. to evaluate texture within the soil horizon.

8. Aspect

This is the compass direction, rounded off to for example SE or NW etc. when looking down the slope. If the terrain is flat complete with a dash.

9. Slope

Slope % is determined by reading a clinometer aimed parallel to the slope.

10. Species Composition

This refers to the stand from which the parent tree was selected. Determine from inventory map or enter an estimate by volume of the main species rounded off to the nearest 10%. Isolated trees older than the main stand should not be included in this volume estimate. Their presence should however be noted.

11. Stand Density

Estimate this item based on comparison with other stands that are of the same age in the selection area.

12. Main Species Vigour

Thrifty = long terminal shoots, healthy colour and long internodes

Good = less vigourous growth but still healthy looking trees

Stagnant = short terminal shoots, dome-shaped tops

Deteriorating = dead tops and branches in crown, minimal height growth, often severe sweeps and leans in the stand.

13. Age Distribution

It is not necessary to establish ages of different trees in the stand. A visual estimate is often sufficient to enable the observer to state that the stand is even aged, two aged or multi-aged.

14. Origin

Self-evident.

15. Site/Stand Comments

Record any further stand comments that are noteworthy (e.g. general phenotypic quality).

PARENT AND OTHER DOMINANT TREE INFORMATION

The information recorded in this section will vary. The minimum requirements for ground and aerial selection are indicated on the form. Additional information may be required as per selection workshops. If more than one dominant is to be measured draw in more dominant tree columns on the form.

16. DBH O.B. (cm)

Diameter at breast height (1.3 meters or 4.5 feet above the germination point) outside bark is entered here in centimeters (1" = 2.54 cm). The germination point on a slope is considered to be halfway between the high and the low point of stem contact with the ground.

17. Double Bark (cm)

Cut through bark to the outermost annual ring and measure bark thickness. Double this figure to yield total bark thickness.

18. DBH I.B. (cm)

This item equals DBH O.B. minus double bark thickness.

19. Height (cm)

Enter total tree height here.

20. Total Age

Count the number rings from the cambium to the pith on a wood core taken at breast height and correct for boring height and distance from the pith. Corrections for boring height are presented in the BCFS Inventory Field Pocket Manual.

21. Stemform

Determine the appropriate stemform value from the coded rating system on the form.

22. Branch Angle

Observe the branches in mid-crown and determine the appropriate branch angle value from the coded rating system.

23. Cone Crop

Determine the appropriate rating based on cone production observations for the species in question. If the date of cone crop evaluation differs from that of selection put this date in brackets beside the cone crop value.

24. Wood Specific Gr.

If specific gravity is to be evaluated wood cores must be sampled and sent to Forintek Canada Corp. for analysis. See Appendix III for wood core sampling instructions. Wood core sampling is not always feasible (e.g. when the weather is very cold or during aerial selection).

25. Competition

Complete a prism sweep using the candidate tree as a centre point. Record the number of trees tallied "in" and the BAF of the prism.

26. Reasons for Selection

Record remarks stating why the tree was selected. It may, for example, be necessary to indicate why a tree was chosen that was smaller than a dominant tree (e.g. perhaps it appeared resistant to a particular pest or exhibited superior form).

LOCATION INFORMATION

27. Country

Self-evident.

28. Prov./State

Self-evident.

29. Nearest Named Geographic Feature

This information should be a major geographic feature that will make locating the parent tree on a map easier.

30. Elevation

Elevation indicates the height of the parent tree above sea level in meters. The newer topographic maps show contour lines in meters above sea level. The older maps show elevation in feet and heights must be converted to metres (feet x 0.305 = metres). Pocket altimeters can also be used to measure parent tree elevation.

31. Orchard Planning Zone

A letter code is used here. Three administrative areas exist in B.C. and are coded: Coast = CO

Central Interior = CI

Southern Interior = SI

Planning zones within each area are further delineated to guide seed orchard and breeding activities. An interm provincial planning zone map is presented in Appendix V. Planning zones are coded as follows:

COAST

Eastern Vancouver Island = EVI
Western Vancouver Island = WVI
Johnstone Straight = JS
South Coast Mainland = SCM
Coast Interior Transition = CIT
Subcontinental = SC
Queen Charlotte Islands Wet = QCIW
Queen Charlotte Islands Moist = QCIM
Mid Coast Moist = MCM
Mid Coast Wet = MCW
North Coast Wet = NCW
North Coast Moist = NCM
Nass Skeena Transition = NST
North Coast Ilands = NCI
Northern Vancouver Island = NVI

CENTRAL INTERIOR

Central Plateau = CP
Bulkley = BLK
Nechako = NCH
McGregor = MGR
Chilcotin = CHL
Cariboo Transition = CT
Big Bar = BB
Quesnel Lakes = QL
Mt. Robson = MRB
Hudson Hope = HH
Upper Finlay = UF
Dease Klappan = DK
Ft. Nelson = FN

SOUTHERN INTERIOR

West Kootenay = WK
Thompson Okanagan Dry = TOD
Shuswap Adams = SA
Thompson Okanagan Arid = TOA
East Kootenay (Acidic) = EKA
East Kootenay (Calcareous) = EKC
Mica = MIC
Bush = BSH

A parent tree selected in the Queen Charlotte Islands Wet zone would for example be coded COQCW.

32. Orchard Number

This item will be completed at the administrative centres when the parent tree is registered.

33. Latitude

Latitude indicated the degrees north of the equator (to the nearest minute) of the parent tree.

34. Longitude

Longitude indicates the distance west of the Greenwich meridian (to the nearest minute) of the parent tree.

35. U.T.M. Grid

Enter the grid coordinates if they are indicated on a topographic map.

36. Forest Region

Indicate as per BCFS administrative boundaries.

37. Forest District

Indicate as per BCFS administrative boundaries.

38. Forest Unit

The name of the timber supply area (TSA), tree farm license (TFL) or park is to be entered here.

39. Location Sketch

This sketch should be a large scale (at least 1:8000 or 1 cm = 80 m) map with an arrow showing north (preferably pointing to the top of the page). On this map roads, bridges, creeks, rivers, lakes, etc. in the direct vicinity of the selected tree must be marked. Clearings, easily recognized trees (such as large cedar snag on roadside, forked cottonwood etc.) or other typical features must be noted; in short, anything that will help a total stranger relocate the tree. Also the location and number of the parent tree, the tie tree and bearing and distance from tie tree to parent tree (see section on tree marking)

should be indicated. Furthermore it helps if the distance in km is marked from the tree to a well-defined point or a mileage marker in the immediate vicinity.

40. General Location Map

The scale of this map can be 1:250,000 (1 cm = 2.5 km) or 1:125,000 (1 cm = 1.25 km) as per the standard topographic maps. The tree location, well-defined points and distances must be marked.

41. Description of Access

It is very important that this is a concise description which corresponds with the Location Sketch and General Location Map because somebody else may have to find the tree later. For ground selection a well-defined point such as a city or major junction or bridge should be the starting point. Mileages from here to turnoffs must be mentioned either separately or cumulatively. Turnoffs must be indicated as left or right and also by compass direction. Location of tiepoint or parent tree must be indicated as ... meters from crossing, fork, edge of clearing etc. and on which side of the road, river or lake. For aerial selection the location sketch and map may alone be sufficient to relocate the tree if completed in detail.

42 - 44.

Self-evident.

45. Selection Method

Indicate the selection method used. The four methods listed are outlined in this guideline.

46 - 47.

Self-evident.

48. Form Checked/Data Coded by

This item is completed by the Ministry of Forests following a check to ensure that all required items are complete and the data has been coded for computer entry.

MARKING OF PARENT TREES

It is most important that selected parent trees be marked and identified in such a manner that they can be easily located by persons other than those making the original selection. Even if a return visit appears unlikely at the time of selection, circumstances may change and dictate the collection of more or perhaps a different type of propagative material.

Parent trees selected on the ground should be marked with a double fluorescent orange (or other easily distinguishable colour) ring painted above breast height around the bole. A large "P" for parent tree or "C" for candidate, if the tree still has to be approved, should also be applied. When dominant trees are measured they are marked with a single ring, a large "D" and number which corresponds to the dominant tree number on the Parent Tree Record Form. Special metal tags can also be used to designate parent trees and are available from the BCFS. Some agencies however prefer not to use these tags because the nails used to attach them can interfere with milling operations. It is finally recommended that parent trees be marked with ribbon to extend visible life of the identifying markers.

Ground selections located within stand will furthermore require a tie-line to a conspicuous tie-point. This line should follow a single compass bearing if possible and be clearly marked with ribbon and/or paint. The tie-point must be located at an easily identifiable location such as a specific road mileage or intersection. This point should also be clearly marked with paint/ribbon and a metal tag, indicating direction and distance to the parent tree. Painted hardwood bark and painted blazes are generally distinguished most easily. Also, if the direction of approach is known upon returning to the tie-point, mark it accordingly. Use plenty of paint and ribbon. These materials are cheap com-

pared to the increased costs of relocating poorly marked trees.

Parent trees located along roads will not require a tie-line. They can however still be troublesome to relocate and the area should thus be well-identified. It is advisable that both sides of the road be marked, especially if the tree lies below road level.

It is important to place all markings above the anticipated snowline since parent trees are often revisited during the winter months. In areas with heavy snow accumulations, normal marking heights may be hidden (especially along roadsides) making relocation most difficult. In addition, when returning to parent trees for any reason, take paint and ribbon. The trees should be remarked so they will remain identifiable for an extended period of time.

Trees selected from the air are commonly marked with two strips of orange pennant cloth (each approx. 1 m x 10 cm) and a length of twine (approx. 75 cm). The twine is wrapped around the upper stem from the helicopter and the strips left hanging alongside the crown. Once marked in this way, the trees appear extremely visible. However these same trees can be most difficult to relocate when revisited months later. It is therefore strongly recommended that aerial selections be located near easily identifiable features such as forks in streams and small lakes to prevent lengthy and expensive relocation efforts

REGISTRATION OF PARENT TREES

Parent trees are formally registered at three administrative centres in the province.[5] Completed Parent Tree Record forms should be forwarded to the appropriate center for registration as soon as possible. Each centre will then:

1. Check the forms to ensure that all shaded items pertaining to ground or aerial selection are completed (see the section entitled "Completion of the Parent Tree Record Form").

2. Allocate permanent registration numbers if local numbers were used during the field work.

3. Copy forms and mail to Systems Services Section of Silviculture Branch, Victoria, propagation centres and geneticists.

4. Maintain complete files of all original forms for planning and general reference.

5. Maintain a current parent tree listing by species, seed zone and agency of selection. Listings by planning zone and elevation band will also be compiled in the future.

6. Plot tree locations by species on maps by planning zone and elevation band.

7. Advise submitting agency that selections have been recorded, plotted on maps and registered giving a list of registration numbers and local numbers.

8. Record wood property data on original parent tree forms (if assessed).

5

Coast	Southern Interior	Northern Interior
Ministry of Forests Coastal Seed Orchards P.O. Box 816 Duncan, B.C. V9L 3Y2	Ministry of Forests Skimikin Nursery General Delivery Tappen, B.C. V0E 2X0	Ministry of Forests Red Rock Nursery R.R. #7 15 Mile Road Prince George, B.C. V2N 2J5

9. Forward a copy of the wood property data to Systems Services section of Silviculture Branch, Victoria and breeding research (if assessed).

A flow diagram of registration procedures on the coast is illustrated in Appendix VI.

REFERENCES

Morgenstern, E.K., M.J. Holst, A.H. Teich, C.W. Yeatman. 1975. Plus-tree selection: review and outlook. Can. For. Serv. Publ. 1347. 72 pp.

Wright, J.W. 1976. Introduction to forest genetics. Academic Press, New York. 463 pp.

Safety Plan -- Use of hydraulic pruner for scion and/or cone collections using helicopter. Silviculture Branch, Ministry of Forests

Guideline for lodgepole pine parent tree selection. Research Branch, Ministry of Forests.

Field Pocket Manual. Inventory Branch, Ministry of Forests.

Western hemlock parent tree selection program. Research Branch, Ministry of Forests.

Coastal Tree Improvement Standards. Silviculture Branch, Ministry of Forests.

APPENDIX I

DEFINITIONS

Genetic Gain. Average improvement in a progeny over the mean of the parents. The amount depends on heritability, selection intensity, parental variation.

Genotype. The entire genetic constitution of an individual.

Heritability. Degree to which a character is influenced by heredity as compared to environment. Narrow-sense heritability is the fraction of total variation that is contributed by additive effects of genes (ratio of additive genetic variance to phenotypic variance). Broad-sense heritability applies to vegetatively propagated species and includes nonadditive effects as well. High heritability indicates that individual phenotypes are indicative of their genotypes.

Orchard Planning Zone. Geographic areas delineated to facilitate seed orchard planning. Generally, seed orchards are developed to primarily serve one planning zone. See provincial map in Appendix V.

Phenotype. The plant or character as we see it; state, description or degree of expression of a character; the product of the interaction of the genes of an individual with the environment.

Provenance Test. An experimental plantation established to compare the performance of trees originating from various geographic locations and to identify superior seed sources.

Selection. Natural: reduction by natural forces (frost, drought, competition, etc.) in the number of individuals in a population contributing to the next generation. Artificial: reduction in the population by man, usually by parent tree selection and subsequent tree breeding activities.

APPENDIX II

Photographs and drawings of good, acceptable and unacceptable interior spruce scion material. Size specifications for other species will vary. However, the requirement of vigorous shoot growth and healthy buds is always important.

Figure A. Good scion material. Vigorous shoot growth and healthy buds.

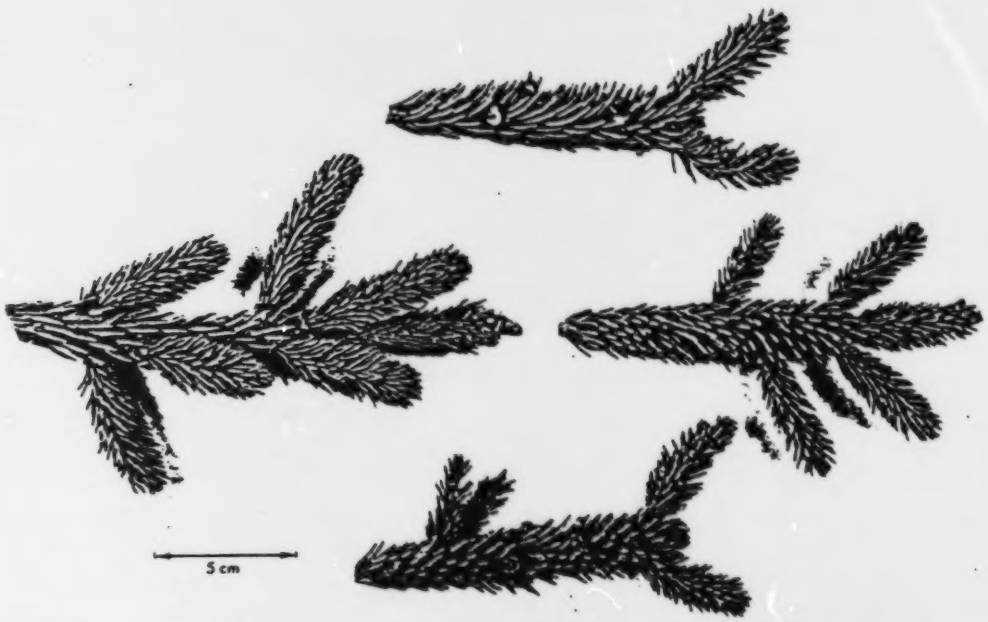


Figure B. Acceptable scion materia - moderate shoot growth and healthy buds.

APPENDIX II CONT'D.

Figure C. Unacceptable scion material - very low shoot vigour due to coincident cone crop and old tree age.

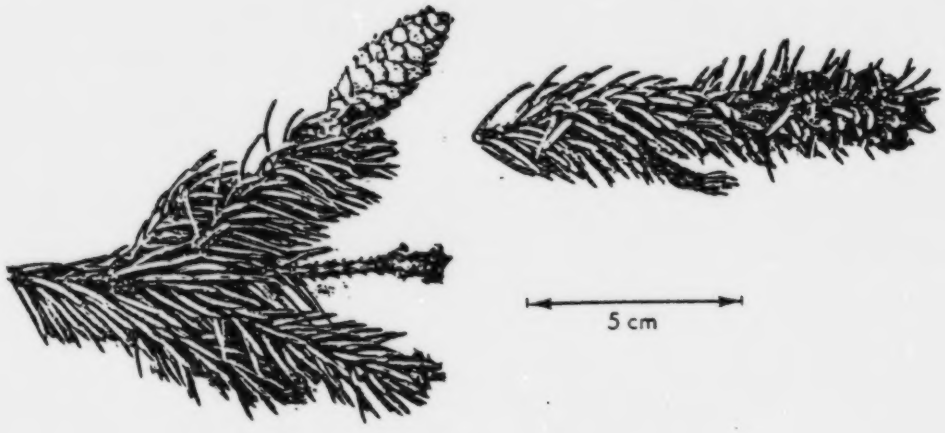


Figure D. Unacceptable scion material - dead buds, low shoot vigour.

GOOD SCION ½ x REAL SIZE

4-9 cm long, 4-8 mm diameter, 3 good buds, straight

no terminal buds, but 3 good buds on lateral.

bent in one plane

two years growth but small node.

ACCEPTABEE SCION ½ x REAL SIZE

more than 8 mm thick

less than 4 mm thick

less than 4 cm long

only two buds

POOR SCION ½ x REAL SIZE

bent in two planes

node too thick

damaged

no buds

UNACCEPTABLE SCION ½ x REAL SIZE

APPENDIX III

Notes on collection of increment cores for specific gravity assessment.

1. Cores should be obtained at breast height with a sharp, standard 4 to 8 mm borer.

2. Trees should be bored to the pith. Two plastic tubes may be required for most radii. In this case try to break the core exactly half way between pith and bark.

3. Two radii per tree should be sampled at 180^{o}.

4. If a tree has even a slight lean, bore on side slope to avoid compression wood and opposite wood.

5. To prevent breakage and facilitate identification, cores should be placed in the numbered plastic tubes provided. The numbers on the tubes should be coded to tree data in this fashion:

Species	DBH	Tree No.	Tube Number	Radious Number
Example:				
Hemlock	27.5	xx	221	2

To ensure correct identification it is also adviseable to record Tree No. and age on water proof paper and put this information alongside the core in the tube.

6. Keep the tubes for each tree together with an elastic band.

7. Place tubes in freezer as soon as conveniently possible to avoid moulding. Freezing should be carried out within 24 hours of collection if at all possible.

8. Keep tubes in plywood box provided and keep accurate data sheet for transmittal with tubes - by first class mail.

9. The importance of obtaining good clean unbroken cores cannot be over

APPENDIX III CONT'D.

emphasized. Torn grain in the core affects the accuracy of the specific gravity determination. We can work with the cores if they are in not more than two or three pieces but more than that is not acceptable.

10. Two cores from one dominant tree should be provided.

11. Send the cores to:

Forintek Canada Corp.
6620 NW Marine Drive
Vancouver, B.C.
V6T 1X2

Attention: Dr. B. Kellogg

APPENDIX IV

III USE OF EDATOPIC GRIDS

The range of soil characteristics within a subzone can be shown schematically on a grid such as the one in Figure 2. This is called an edatopic grid, from edaphos meaning soil, since it presents two major soil factors: soil moisture on the vertical axis and soil nutrients on the horizontal axis.

The soil moisture regime refers to moisture available to vegetation during the growing season (May to September) and must be judged from soil characteristics and not by the moistness of the soil at one particular time. Definitions of the soil moisture classes are provided below. Basically soil moisture availability increases from 0 to 7.

0 Very Xeric - water removed extremely rapidly in relation to supply; soil is moist for a negligible time after precipitation.

1 Xeric - water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation.

2 Subxeric - water removed rapidly in relation to supply; soil is moist for short periods following precipitation.

3 Submesic - water removed readily in relation to supply; water available for moderately short periods following precipitation.

4 Mesic - water removed somewhat slowly in relation to supply; soil may remain moist for a small, but significant, period of the year.

5 Subhygric - water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possibly mottling below 20 cm.

6 Hygric - water removed slowly enough to keep the soil wet for most of the growing season; permanent seepage and mottling present; possibly weak gleying.

7 Subhydric - water removed slowly enough to keep the water table at or near the surface for most of the year; gleyed mineral or organic soils; permanent seepage less than 30 cm. below the surface.

The soil nutrient regime refers to availability of nutrients (primarily

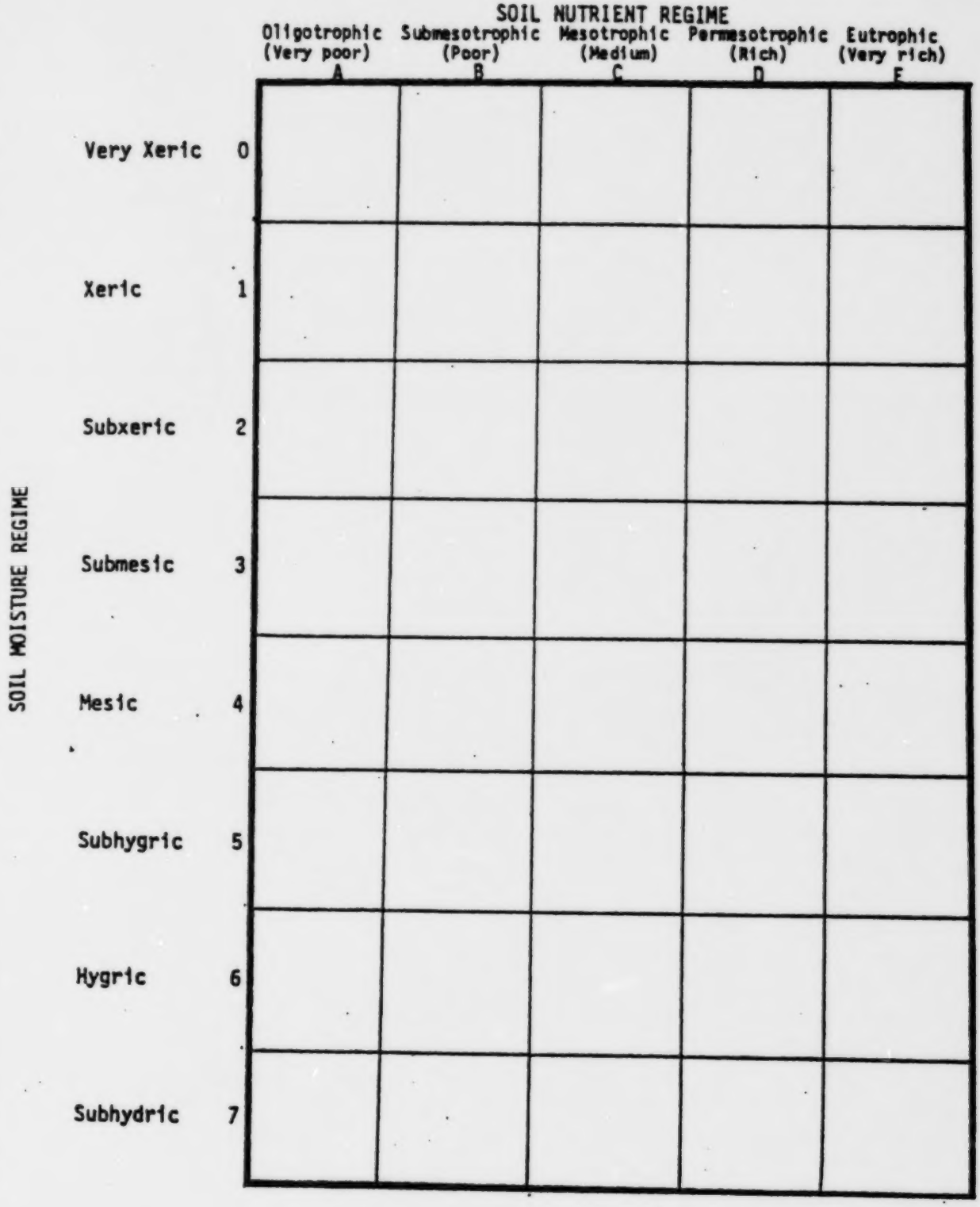


Figure 2 Edatopic Grid

positively charged ions or cations) for plant growth. Definitions of the soil nutrient classes are as follows:

A Oligotrophic (very poor) - available nutrient supply is small; soils are strongly to extremely acid with low Cation Exchange Capacity (CEC) and low Base Saturation (BS); soil organic layers have high carbon/nitrogen (C/N) ratios.

B Submesotrophic (poor) - available nutrient supply is low; soils are moderately to strongly acid with moderate to low CEC and BS; soil organic layers have moderate to high C/N ratios.

C Mesotrophic (medium) - available nutrient supply is moderate; soils are moderately acid to neutral with moderate CEC and BS; soil organic layers have moderate C/N ratios.

D Permesotrophic (rich) - available nutrient supply is plentiful; soils are slightly acid to mildly alkaline with moderate to high CEC and BS; soil organic layers have moderate to low C/N ratios.

E Eutrophic (very rich) - available nutrient supply is very abundant; soils are neutral to moderately alkaline with high CEC and BS; soil organic layers have low C/N ratios.

The edatopic grid can therefore portray all possible combinations of soil moisture and nutrient status from very dry - low nutrient (0-A) to wet - high nutrient (7-E). Box 4-C approximates the mesic site within each subzone.

IV DETERMINATION OF EDATOPIC POSITION

A. Soil Moisture

Actual soil moisture is seasonally variable, so that during the spring runoff all soils will appear somewhat moist. However, soil moisture here refers to the amount of water the soil is able to supply for plant growth during the growing season. This estimation must also be made within the framework of the particular subzone; for example a mesic site in the ID/d subzone will be much drier than a mesic site in the IwH/w simply because of significant differences in precipitation input. Therefore the moisture regime must be judged in relation to the precipitation supply which is constant for a subzone but highly variable between subzones.

As well as macroclimatic influences, certain topographical and soil characteristics play an important role in determining soil moisture. These characteristics are defined for each moisture regime class in Table 2 and are explained in more detail below.

1. Slope Position and Aspect

In general, the most influential factor is the position on the slope. Ridges and upper slopes are shedding positions, i.e. precipitation is the main water source and it passes quickly downslope as seepage so there is little, if any, retention of moisture. Mid to lower slopes will receive in addition to precipitation some seepage from upslope but it will move further downslope and only some moisture may be retained. Also, the seepage flow will be discontinued during the summer. Precipitation is, therefore, a main water source here also (see Figures 3 and 4). Lower slopes, flats (terraces) and depressions are receiving positions and may receive most of their moisture through seepage which remains throughout the growing season, although if soil texture is sufficiently coarse, the moisture may be at a depth which is unavailable to the vegetation (see Figure 5). Sloping areas in general will receive less input from precipitation because more of it will run off than on flatter areas, and the steeper the slope the greater the difficulty in holding moisture. Aspect is also important; the warm (south) aspect usually decreases the amount of available soil moisture.

#	Hygrotope or Moisture Regime	Characteristics	Slope Position	Primary Water Source	Soil Properties			
					Drainage	AWSC*	Texture	Depth
0	VERY XERIC	Water removed extremely rapidly in relation to supply; soil is moist for a negligible time after ppt.	ridge crests, shedding positions	ppt.	excessively to rapidly	extremely low	very coarse	very shallow to shallow
1	XERIC	Water removed very rapidly in relation to supply; soil is moist for brief periods following ppt.	ridges, terrace tops with very coarse materials, shedding positions	ppt.	very rapidly to rapidly	very low	very coarse to coarse	shallow
2	SUBXERIC	Water removed rapidly in relation to supply; soil is moist for short periods following ppt.	ridges, upper slopes, terrace tops with coarse materials, shedding positions	ppt.	rapidly to well	low	coarse to moderately coarse	shallow to moderately deep
3	SUBMESIC	Water removed readily in relation to supply; water available for moderately short periods following ppt.	mid to upper slopes, terrace tops with moderately coarse materials	ppt.	rapidly to moderately well	low to intermediate	moderate to fine	moderately deep
4	MESIC	Water removed somewhat slowly in relation to supply; soil may remain moist for a small, but significant period of the year	mid slopes, flats, terraces of moderate texture	ppt. in moderate to fine textured soils and limited seepage in coarse textured soils	low to intermediate	intermediate	moderate to fine	moderately deep to deep
5	SUBHYGRIC	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possibly mottling below 20 cm.	mid to lower slopes, receiving positions with coarse textured materials	ppt. and seepage	moderately well to imperfectly	variable	variable	deep
6	HYGRIC	Water removed slowly enough to keep the soil wet for most of the growing season; permanent seepage and mottling present; possibly weak gleying	lower slopes, receiving positions	seepage	imperfectly to poorly	variable	variable	variable
7	SUBHYDRIC	Water removed slowly enough to keep the water table at or near the surface for most of the year; gleyed mineral or organic soils; permanent seepage less than 30 cm below the surface	lower slopes, depressions receiving positions	seepage or permanent water table	poorly to very poorly	variable	variable	variable

Table 2 Moisture Regime Characteristics.

*Available Water Storage Capacity

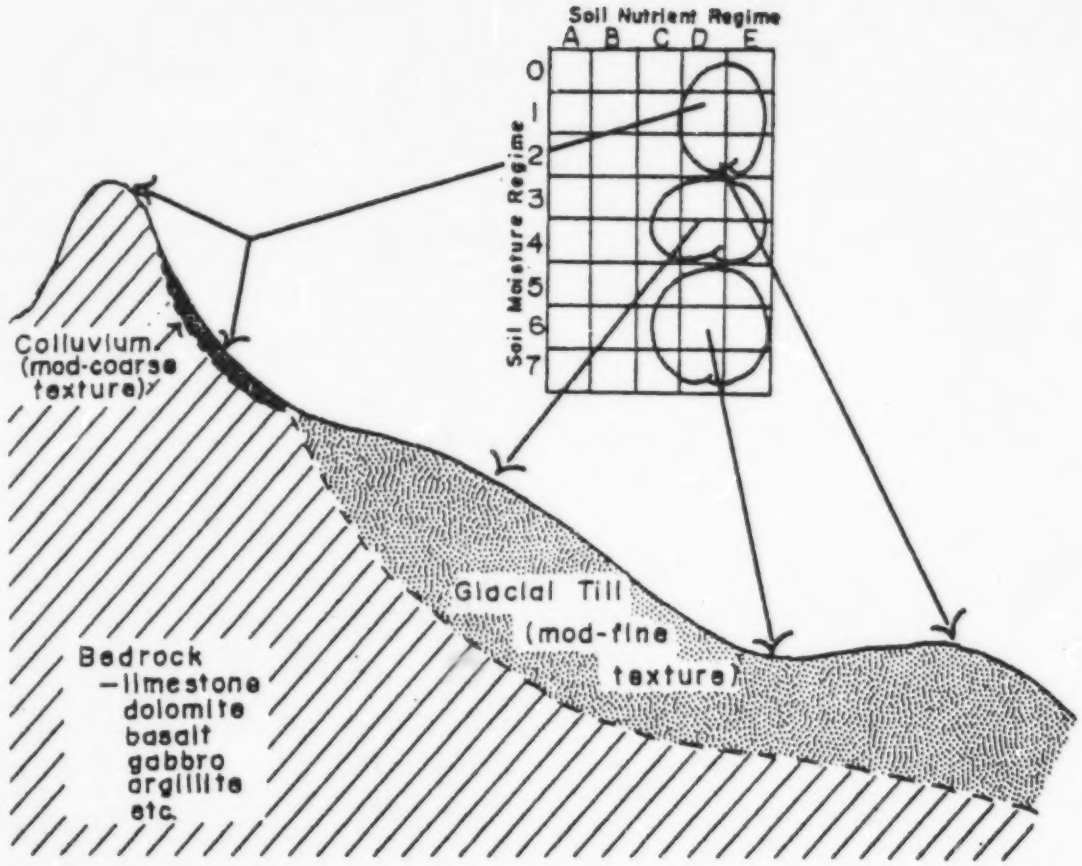
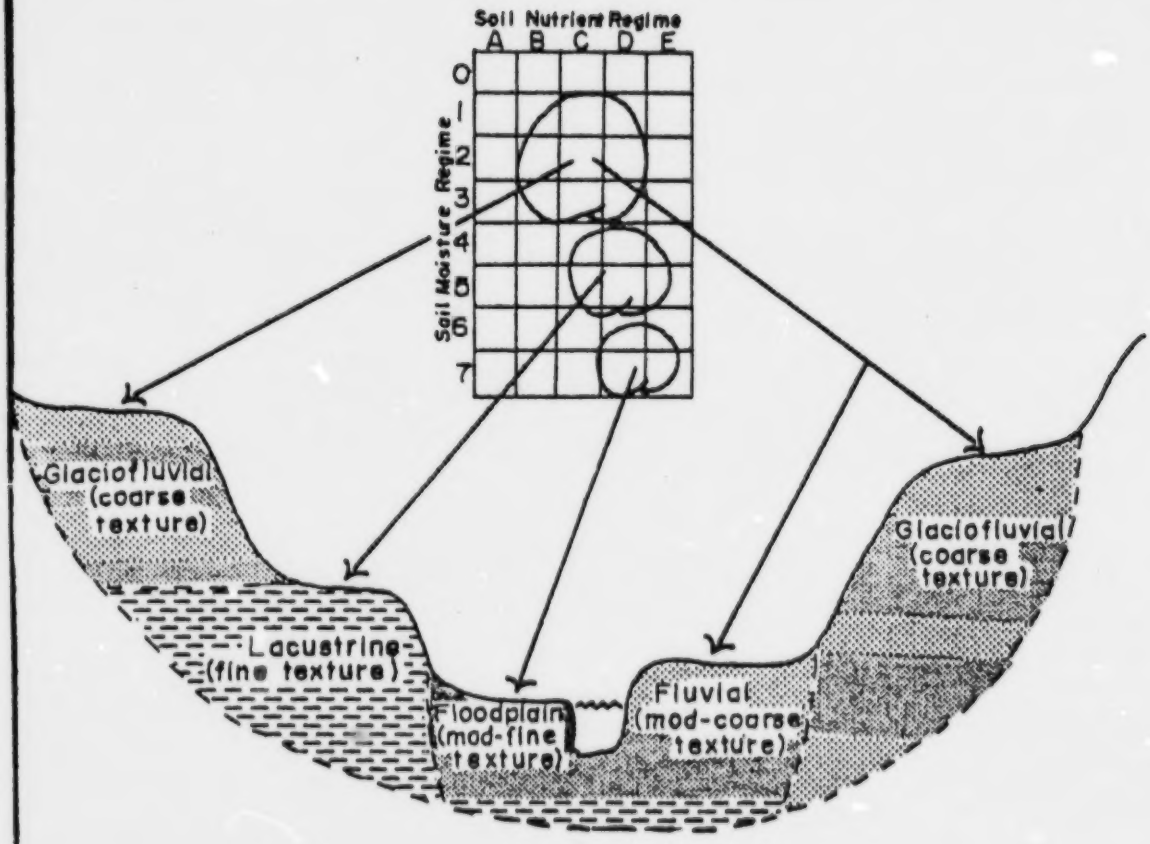


Figure 4 Valley Slope -- Medium to Rich Bedrock Types



Note: these landforms generally consist of a mixture of materials and are therefore not directly affected by the type of underlying bedrock

Figure 5 Valley Bottom

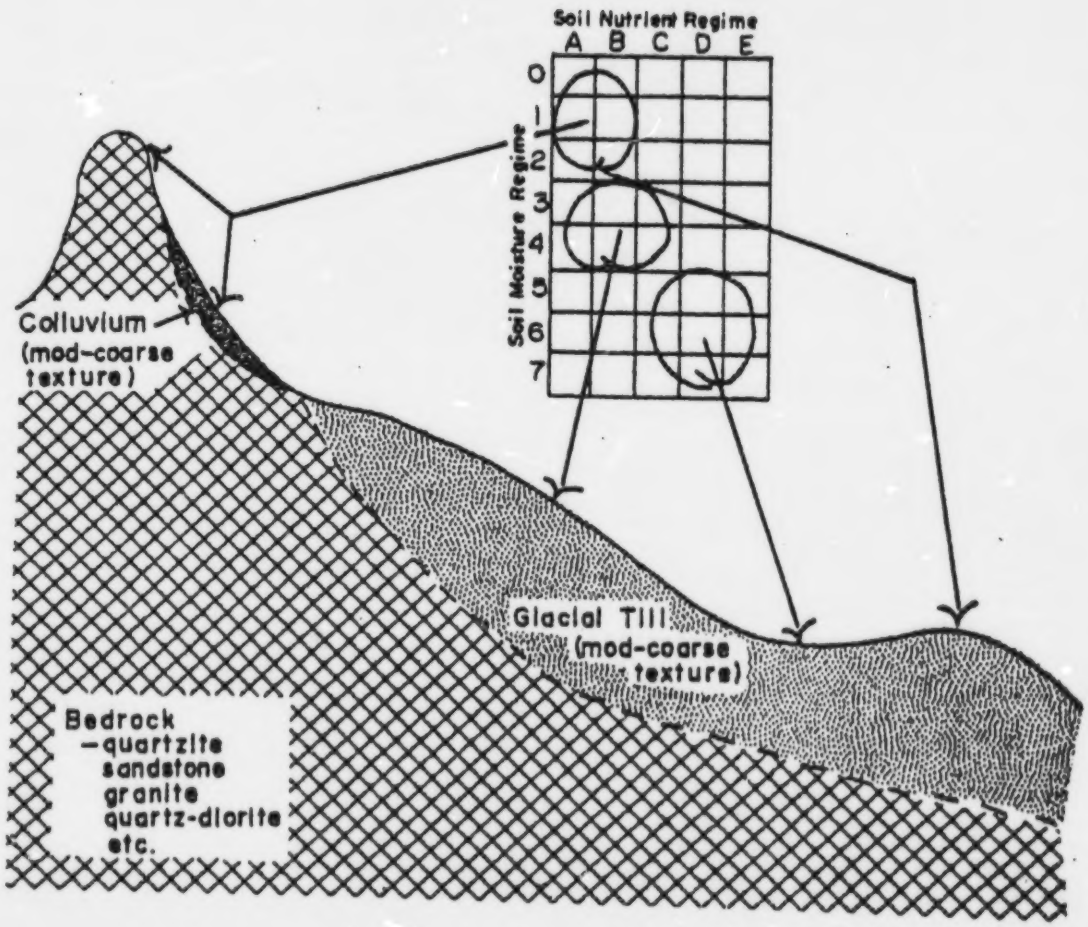


Figure 3 Valley Slope -- Very Poor to Medium Rich Bedrock Types

2. Soil Texture and Depth

Soil texture has a significant effect on the water holding capacity of soils. Fine-textured soils (silts, clays, loams*) have a greater capacity than coarse, sandy soils. However, soil texture and slope position may interact to produce compensating effects. For instance, a fine textured soil on a steep upper slope will be drier than a coarse soil in a depression with permanent seepage. In addition to the effect of the fine fraction of the soil (less than 2mm), inclusions of coarse fragments (gravels, stones, etc.) can greatly reduce water holding capacity. In contrast, organic matter incorporated into the soil enhances water holding capacity. Deeper soils are also able to hold more moisture than shallow soils and the presence of an impermeable layer (e.g. bedrock, compacted till, cemented layer) may create conditions for temporary or permanent subsurface flow.

B. Nutritional Status

Soil nutrient regime is an estimation of the available nutrient supply to plant growth with emphasis on soil pH and exchangeable cations such as Ca, Mg, Na and K which are essential for tree growth. In general soil pH, the availability of these cations and tree growth will all increase going from oligotrophic (very poor) to eutrophic (very rich). However, there are situations at high pH's in particular where certain essential nutrients become fixed and unavailable (e.g. phosphorus). Tree species also are adapted to using nutrients in particular forms, for example, Western Hemlock's best growth will be in oligotrophic to submesotrophic situations because it prefers nitrogen in a form which is available at low pH's.

The soil nutrient regime must be judged within the framework of a particular subzone, just as the soil moisture regime is. An estimation must be made of the relative occurrence of very poor to very rich regimes within a subzone. For example, a subzone with lower precipitation (e.g. ID/d) will have less soil leaching and therefore relatively richer, more basic soils than one with high precipitation and increased soil leaching (e.g. IwH/w). Therefore the mesic site will be richer in ID/d than in IwH/w.

*loam is soil comprised of up to 25% clay, 25-50% silt and less than 50% sand; as percentages of each component vary, loam can be further described as sandy loam, silt loam, clay loam, etc.

The following sections provide information on several factors which can be utilized to give an estimation of soil nutrient regime. As much as possible, the effects of all the factors should be considered together.

1. Soil Parent Materials (bedrocks and landforms)

The kind of bedrock from which the soil parent materials were derived can be a useful guide. Identification of coarse fragments from the soil is preferable, however local outcrops or information from a geologic map may be used.

During the last major glaciation, glacial materials were mainly derived from local bedrock sources, producing soil parent materials which reflect local bedrock characteristics. This is particularly true in small valley systems where the bedrock is uniform and materials have moved short distances. The larger valleys are more likely to have mixed parent materials of intermediate nutrient regimes. Wherever bedrock is used as the primary differentiating criteria the rock types which occur as coarse fragments should be compared with those indicated on geologic maps or in adjacent outcrops.

Soils derived from basic igneous rocks (e.g. basalt, gabbro, diorite), basic metamorphic rocks (e.g. greenstone, biotite schist, gabbro gneiss), and rich sedimentary rocks (e.g. limestone, dolomite, argillite) may be expected to be mesotrophic to subeutrophic nutrient regimes due to the abundance of basic elements or macro-nutrients found in the minerals of these rocks. These rock types also generally result in finer textured materials (loamy to clayey) than the more resistant acidic bedrock types. Soils derived from acid igneous rocks (e.g. rhyolite, granite, quartz monzonite), acid metamorphic rocks (e.g. quartzite gneiss, quartz schist, quartzite), and some sedimentary rocks (e.g. quartz sandstone) may be expected to be oligotrophic to mesotrophic. The soil textures are usually sand, sandy loam or loamy sand. See Figures 3, 4 and 5.

2. Landforms and Soil Texture

Landforms may assist in predicting nutritional status because they are partially defined on the basis of a uniform texture.

Inferences from texture are based on the relationship between clay and the ability of the soil to retain positively charged ions (i.e. cations) among which are several nutrient forms (e.g. potassium, calcium). This ability of the soil is called cation exchange capacity. It increases as the proportion of clay increases, since the relatively greater surface area

of the small clay particles provides a greater capacity for holding cations.

Thus coarse textured soils developing from glaciofluvial and fluvial deposits (outwash, kames, kame terraces) can be expected to be of poor to medium (B-C) nutrient status, whereas finer textured soils developing from lacustrine and floodplain deposits can be expected to be of rich to very rich (D-E) nutrient regimes. Refer to Figure 5. Soils developing from glacial tills will primarily fall in the medium nutrient regime; however, if they are derived from one bedrock source, they will be affected more strongly by the type of bedrock and may range from poor to rich. Colluvial soils are generally of poor (A-B) nutrient status because of coarse texture; however those derived from sedimentary rock (limestone, dolomites, etc.) may be medium to rich. Refer to Figures 3 and 4.

3.Soil Organic Layers

Soil organic layers may be classified into three major humus forms: mor, moder, and mull. The humus form, reflecting the mode of decomposition, is related to many environmental factors (e.g. microclimate) and biotic factors (e.g. chemical characteristics of litter-fall). It is identified by the relative proportions of the three layers (L-fresh litter; F-fermented or felty partially decomposed litter with observable structure; and H-humified amorphous and colloidal material); the total thickness of all layers; an estimate of soil, animal or fungi activity; and by analytical parameters such as pH and C/N ratio. In general, the humus form reflects the kind and degree of decomposition of organic matter, and hence is a good indicator of the intensity of biogeochemical cycling.

Mor humus is the most acid (pH 3-5) and has a high C/N ratio (>30). L, F and H are present, with F or H predominating. It is usually underlain, particularly in coarse textured soils, by an Ae horizon (a gritty, grey-white layer). The presence of an Ae horizon indicates substantial leaching of nutrients from the mineral soil and is accompanied by an accumulation of slowly available nutrients in mor humus. Decomposition of organic material is primarily by fungal action. Mor humus usually indicates oligotrophic to mesotrophic nutrient regimes.

Moder humus is intermediate in acidity (pH 4-6), C/N ratio (20-30) and thickness. The L, F and H may be present in roughly equal proportions, or the H layer may be completely lacking. Decomposition results from action by animals, microorganisms and to a lesser degree by fungi. Moder humus usually indicates mesotrophic to subeutrophic nutrient regimes.

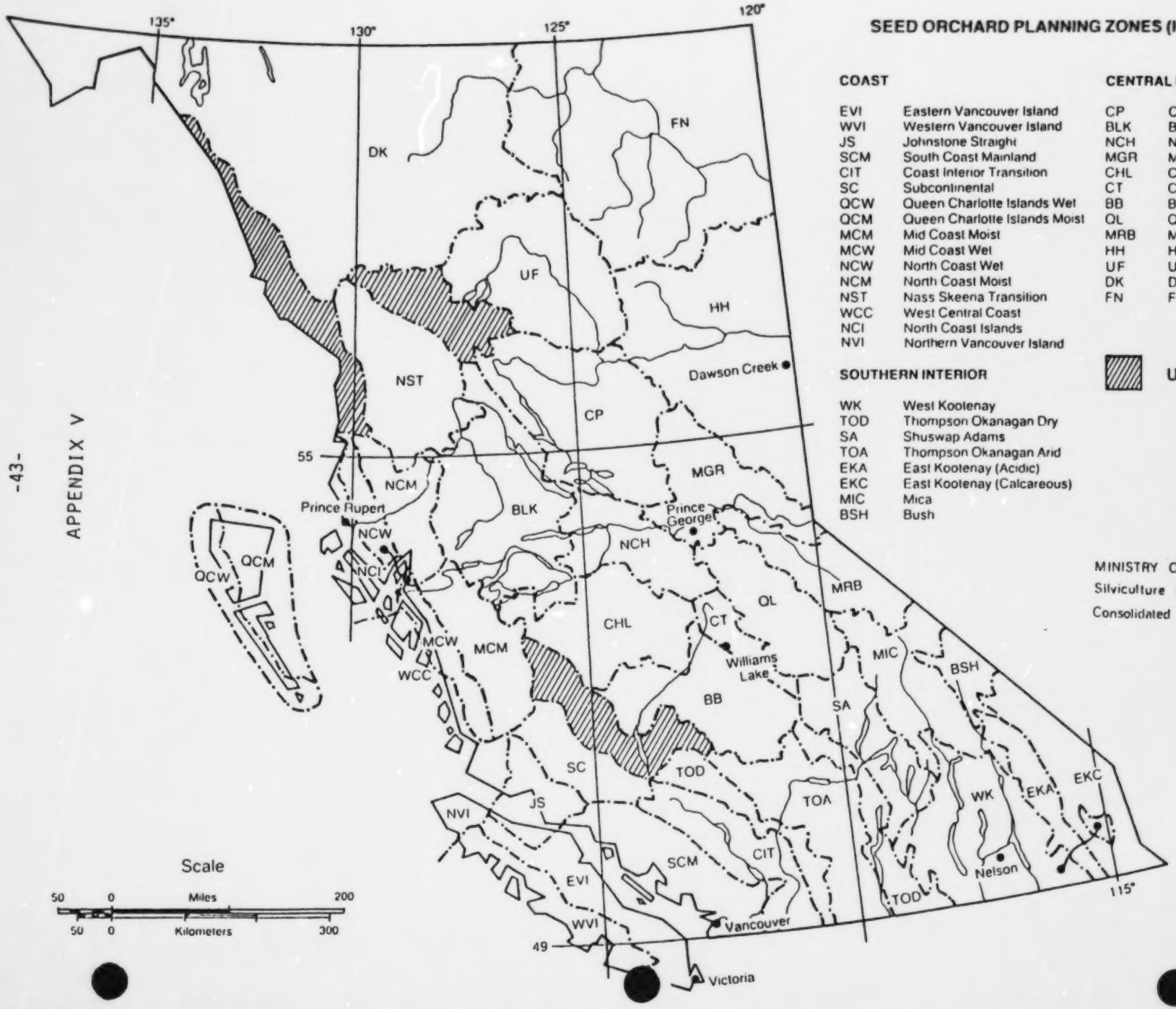
Mull humus is slightly acid to neutral (pH 5-7), has a low C/N ratio (<20), and is typically found on grasslands and under deciduous stands. It is characterized by little or no L or F, and a thin H underlain by a dark mineral soil horizon (Ah) resulting from the incorporation of organic matter by earthworms and other soil fauna. Mull humus usually indicates permesotrophic to eutrophic nutrient regimes.

Dark colored soils in general indicate that organic matter has been incorporated into the soil, thereby increasing soil fertility because of its fine texture and resulting ability to hold nutrients.

4. Seepage Water

The presence of temporary or permanent subsurface water flow within the rooting zone (which is easily observable on road cuts) indicates rich to very rich (D-E) nutritional status due to the influx of nutrients in the water. Similarly, alluvial fans with moving underground water have rich to very rich status. Seepage water emanating from acid bogs is an obvious exception.

APPENDIX V



SEED ORCHARD PLANNING ZONES (INTERIM)

COAST

EVI	Eastern Vancouver Island
WVI	Western Vancouver Island
JS	Johnstone Straight
SCM	South Coast Mainland
CIT	Coast Interior Transition
SC	Subcontinental
QCW	Queen Charlotte Islands Wet
QCM	Queen Charlotte Islands Moist
MCM	Mid Coast Moist
MCW	Mid Coast Wet
NCW	North Coast Wet
NCM	North Coast Moist
NST	Nass Skeena Transition
WCC	West Central Coast
NCI	North Coast Islands
NVI	Northern Vancouver Island

CENTRAL INTERIOR

CP	Central Plateau
BLK	Bulkley
NCH	Nechako
MGR	McGregor
CHL	Chilcotin
CT	Cariboo Transition
BB	Big Bar
OL	Quesnel Lakes
MRB	Mt. Robson
HH	Hudson Hope
UF	Upper Finlay
DK	Dease Klappan
FN	Ft. Nelson

SOUTHERN INTERIOR

WK	West Kootenay
TOD	Thompson Okanagan Dry
SA	Shuswap Adams
TOA	Thompson Okanagan Arid
EKA	East Kootenay (Acidic)
EKC	East Kootenay (Calcareous)
MIC	Mica
BSH	Bush

Unclassified

MINISTRY OF FORESTS
Silviculture Branch
Consolidated Oct. 1980

APPENDIX VI

PARENT TREE SELECTION and REGISTRATION FLOW CHART - Coastal Admin. Area.
(Similar Flow Chart applies to Interior Admin. Areas)